CRYSTAL, EOS Validation and CAMEX-5

- **CAMEX-relevant Future Field Missions**
  - CRYSTAL-TWP
  - TC3 (Aura Validation)
- **Paradigm for Major NASA Field Missions**
  - Science Question Driven
  - Satellite Validation Relevant
  - Multi-Program Participation
  - Interagency Participation/Application

Planned EOS Aura Validation Missions

The A-Train……

Aqua (5/02) - MODIS, CERES, AIRS, AMSR-E

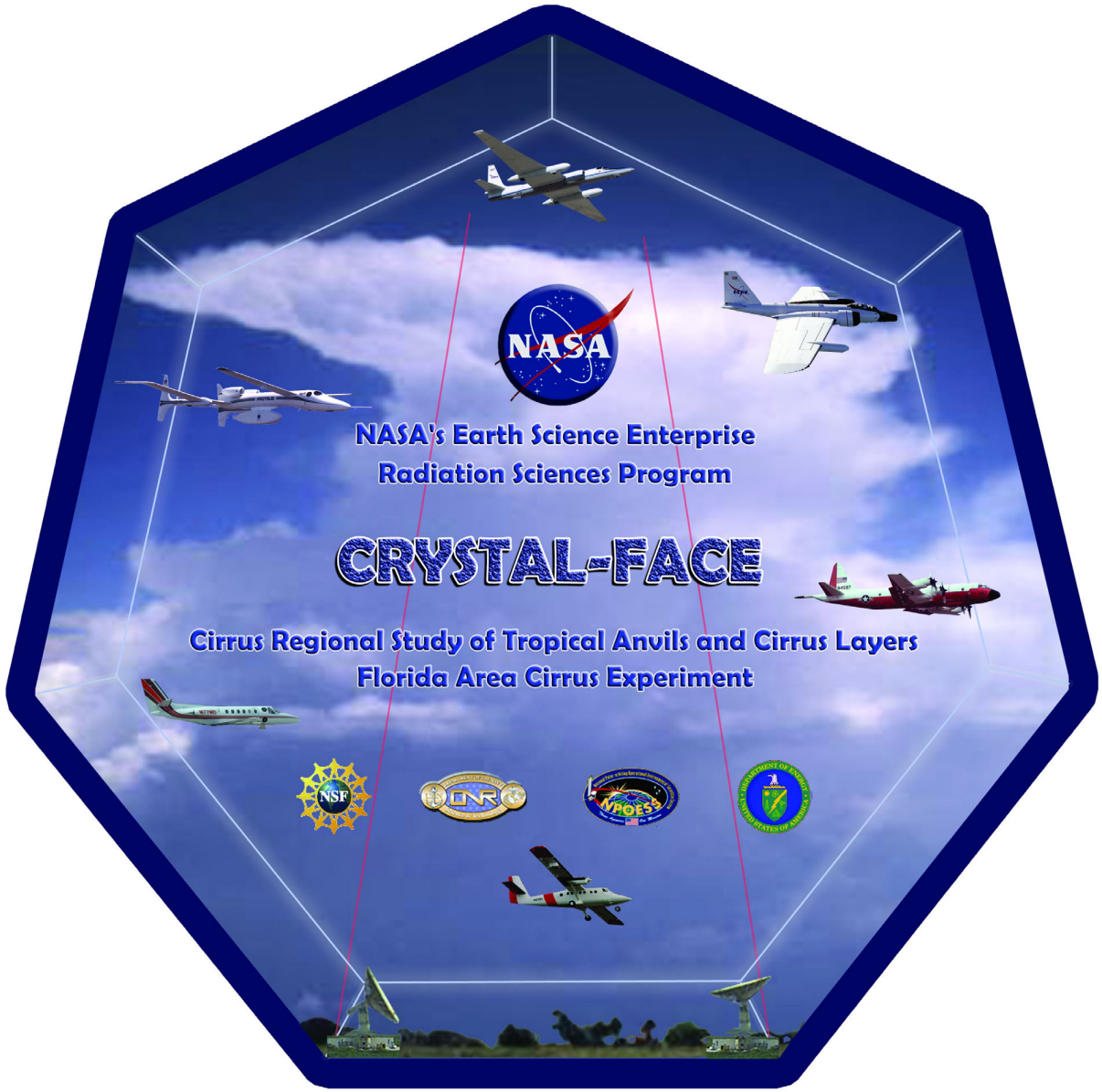
Aura (1/04) - MLS, HIRDLS, OMI, TES

CloudSat (4/04)

CALIPSO (4/04)

- ***Major Field Missions…..***

INTEX-East	(ER-2, DC-8, P3)	summer 2004
TC3	(ER-2, WB-57, DC-8)	winter 2005
CRYSTAL-TWP	(ER-2, WB-57, DC-8)	summer 2005
INTEX-West	(ER-2, DC-8, P3)	spring 2006


NASA
NASA's Earth Science Enterprise
Radiation Sciences Program
CRYSTAL-FACE
Cirrus Regional Study of Tropical Anvils and Cirrus Layers
Florida Area Cirrus Experiment
NSF
ONR
NPOESS

D. Starr/GSFC

CRYSTAL-FACE Sponsors

- **NASA Radiation Sciences Program** (Don Anderson)
- NASA Upper Atmosphere Research Program (Mike Kurylo)
- **NASA EOS Validation Program** (Michael King)
- NASA Atmospheric Chemistry Modeling and Analysis Program (Phil DeCola)

- **National Science Foundation** (National Center for Atmospheric Research)
- Department of Energy Atmospheric Radiation Program (ARM)
- **Office of Naval Research** (CIRPAS)
- Integrated Program Office (NPOES)

- Cooperating Agency: NOAA National Weather Service

CRYSTAL and NASA ESE Science Questions

a) How are global precipitation, evaporation and cycling of water changing? (Variability)

b) What trends in atmospheric constituents and solar radiation are driving global climate? (Forcing)

c) What are the effects of clouds and surface hydrologic processes on Earth's climate? (Response)

CRYSTAL-FACE Science Goals

- **Improve understanding/models of cirrus anvil properties in relationship to the properties and strength of deep convection.**

  Does stronger convection imply a larger longer-lived anvil? ...more anvil ice mass? ...larger ice crystals? ...more complex ice crystals?

  => Link **convective mass flux** to anvil properties.

- **Improve understanding/models of the factors that control lifetime and area coverage of cirrus anvils and tropical cirrus layers.**

  What is role of cirrus cloud processes? (radiation, microphysics, dynamics)

  => Study physical properties and processes of persisting anvils and cirrus over lifetime. Characterize dependence on environmental controls.

How well are cloud-generating/dissipating processes represented in cloud system models? ….in global models? How should they be represented?

CRYSTAL-FACE Science Goals

- **Improve understanding of how deep convection affects tropical upper tropospheric humidity** (key climate-radiation variable).

  How are TTL cirrus layers and humidity related to cb-generated cirrus?

  => Measure upper tropospheric humidity and other tracers of convection.

- **Improve understanding of processes that control lower stratospheric humidity** (key factor in stratospheric chemistry*).

  What processes control the transport of mass and water from the troposphere to the stratosphere?

  => Measure water vapor accurately along with temperature, water isotopes, cloud microphysics, and tracers near the tropical tropopause.

* Lower stratospheric water vapor is important factor in stratospheric chemistry. Nature and strength of troposphere-stratosphere exchange is not well understood in tropics (competing theories).

D. Starr/GSFC

CRYSTAL-FACE Science Goals

- **Validate remote-sensing measurements**

  => Obtain diverse remote sensing and in-situ information about properties of tropical cirrus, and relate these data to concurrent measurements from ground-based, airborne, and satellite remote sensors.

  Terra (MODIS, MISR, CERES), **Aqua** (MODIS, AIRS, CERES)

  TRMM (Precipitation radar)

  Up/down-looking cloud/aerosol lidar (**CALIPSO**-like)

  Up/down-looking millimeter cloud radar (**CLOUDSAT**-like)

  GOES, POES, etc….

CRYSTAL-FACE Observing Platforms

Satellites: **Terra, Aqua, TRMM, GOES, POES**

Aircraft and Science Team at Key West Naval Air Station

NASA ER-2	Remote sensing, satellite simulator, *in-situ*
Proteus	Remote sensing, satellite simulator
NASA WB-57	*In-situ* microphysics and chemistry
UND Citation	*In-situ* cloud microphysics
CIRPAS Twin Otter	*In-situ* aerosol, chemistry, microphysics
Navy P3	NCAR ELDORA Doppler cloud radar

Eastern Site	Remote sensing, radiation
Western site	Remote sensing, radiation, soundings
NPOL site	NPOL Doppler radar, a/c ops control
NWS sites	NEXRAD (4), rawinsondes (3)

D. Starr/GSFC

Ground Sites

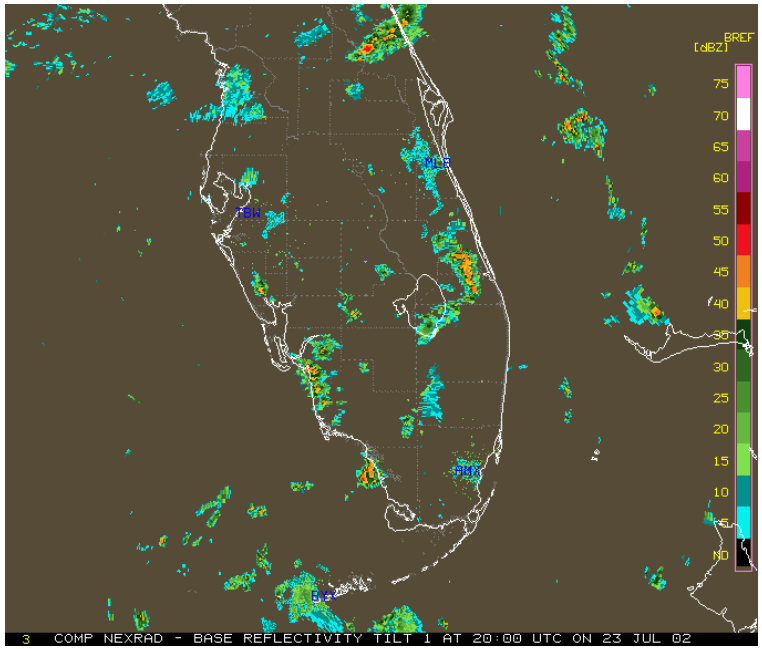
Western Ground Site

NPOL

Eastern Ground Site


PROTEUS
N281PR
NASA
DRYDEN

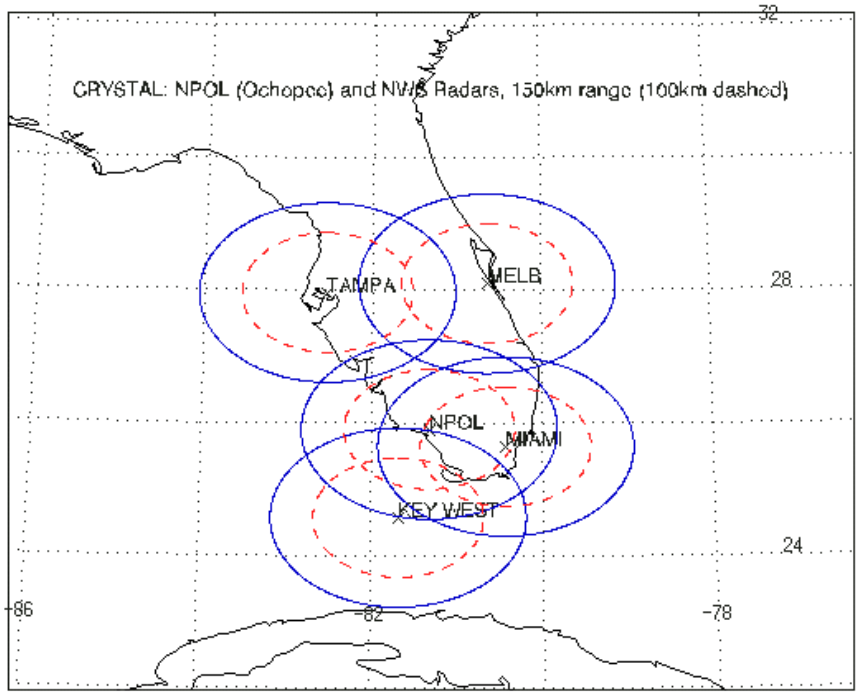
CRYSTAL-FACE Radar/Sonde Networks



- Precipitation morphology observations (context for mass flux and CRM simulations).
- Enable internet access to 88-D data (CRAFT).
- Polarimetrically-tuned rainmaps from 88-D data "piggy-backing" from NPOL

Enhanced Sounding for CRM simulations

- NWS: MFL, TBW, *EYW*
- Mobile station
- Western Site Station (PARCL)
- ER-2 Dropsondes



D. Starr/GSFC

CRYSTAL-FACE People

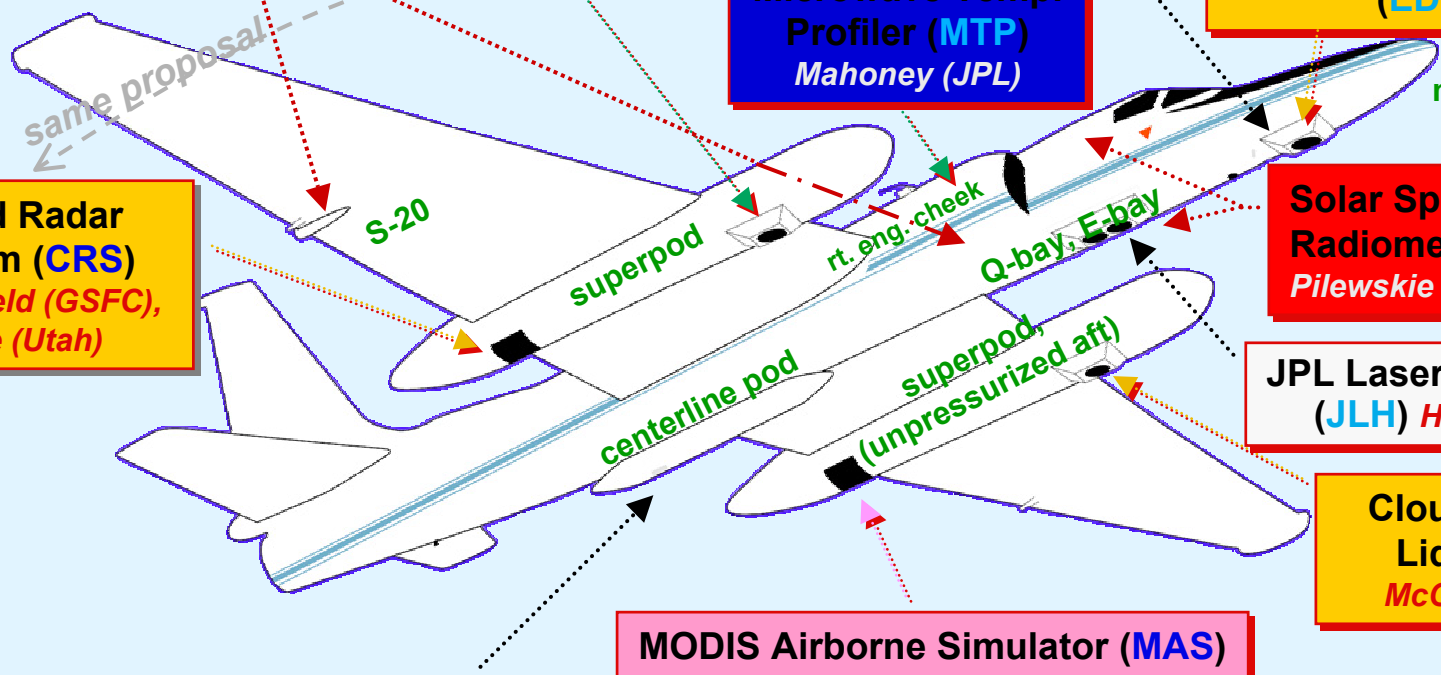
- **Mission Scientist - Eric Jensen**

  Co-Mission Scientists - Brian Toon, David Starr

  Platform Scientists - *the room gets crowded…..*

- **200+ scientists at Key West NAS**
- **Strong Theory and Forecast Teams in Field**
  - Mesoscale/Cloud Systems Models (3)
  - Trajectory Models
  - Satellite and Radar Data and Analysis
  - CRYSTAL, NWS and Navy Forecasters

CRYSTAL-FACE ER-2 Instrument Payload



Radiation Meas. System (RAMS) *Valero (Scripps)*

Conical Scanning Sub-mm wave Imaging Radiometer (COSSIR) *Wang (GSFC), Evans (CU)*

Meteorological Meas. System (MMS) *Bui (Ames)*

Microwave Temp. Profiler (MTP) *Mahoney (JPL)*

ER-2 Doppler Radar (EDOP)

Cloud Radar System (CRS) *Heymsfield (GSFC), Mace (Utah)*

Solar Spectral Flux Radiometers (SSFR) *Pilewskie (Ames)*

JPL Laser Hygrometer (JLH) *Herman (JPL)*

Cloud Physics Lidar (CPL) *McGill (GSFC)*

MODIS Airborne Simulator (MAS) *King (GSFC), Platnick (UMBC)*

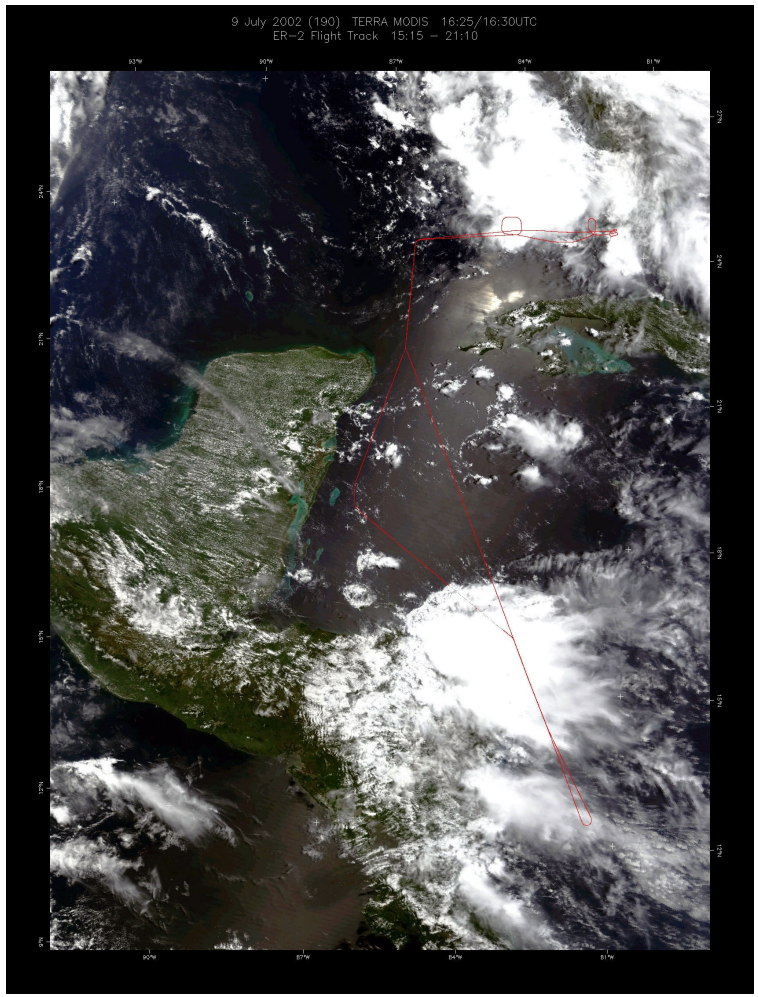
Vaisala Dropsonde *Halverson (UMBC), Starr (GSFC)*

D. Starr/GSFC

S. Platnick, July 2002

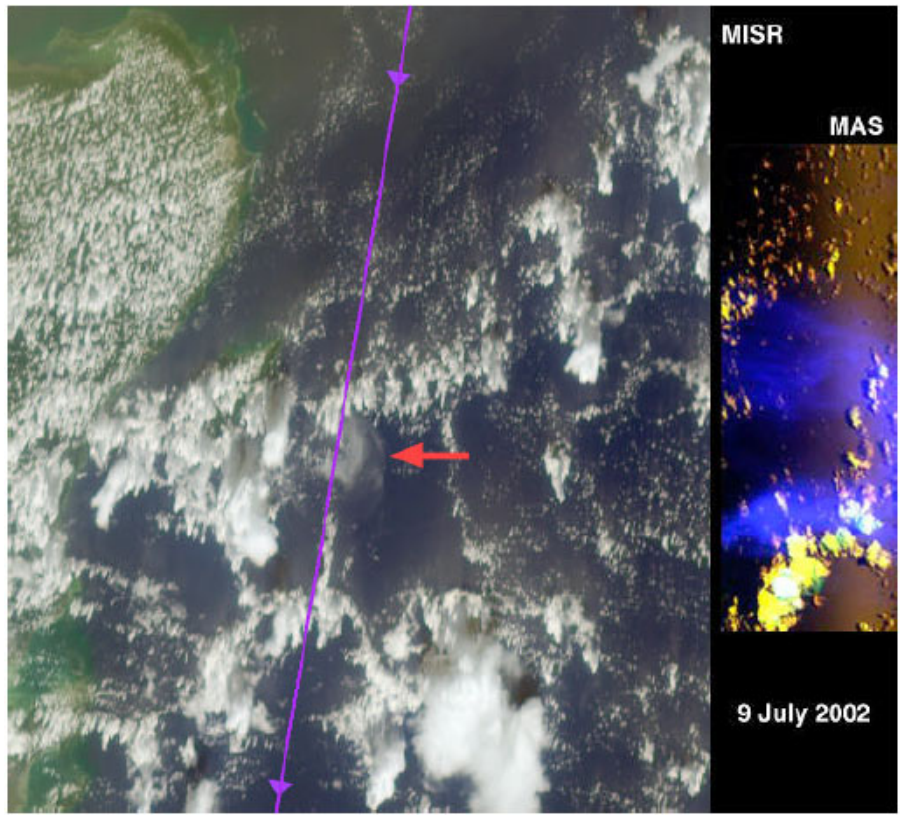
CRYSTAL-FACE: Deep Tropics Mission
July 9, 2002

Terra MODIS



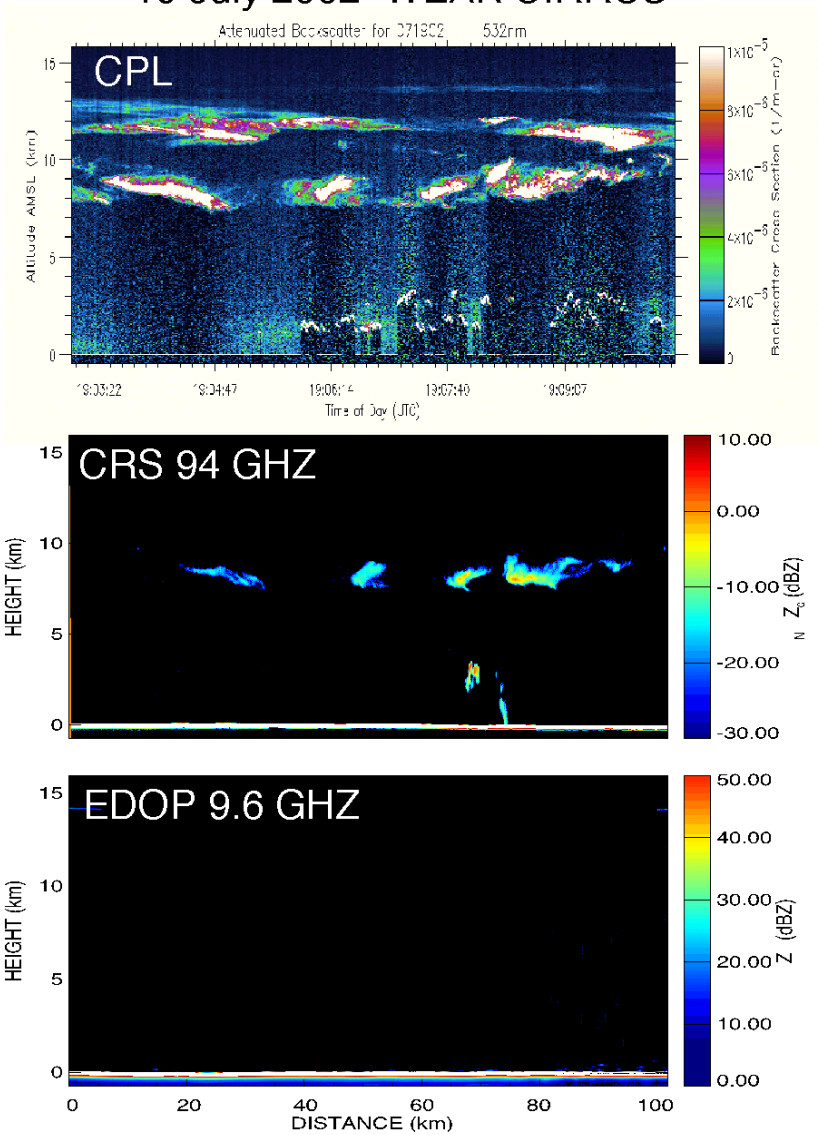
Terra MISR

MAS

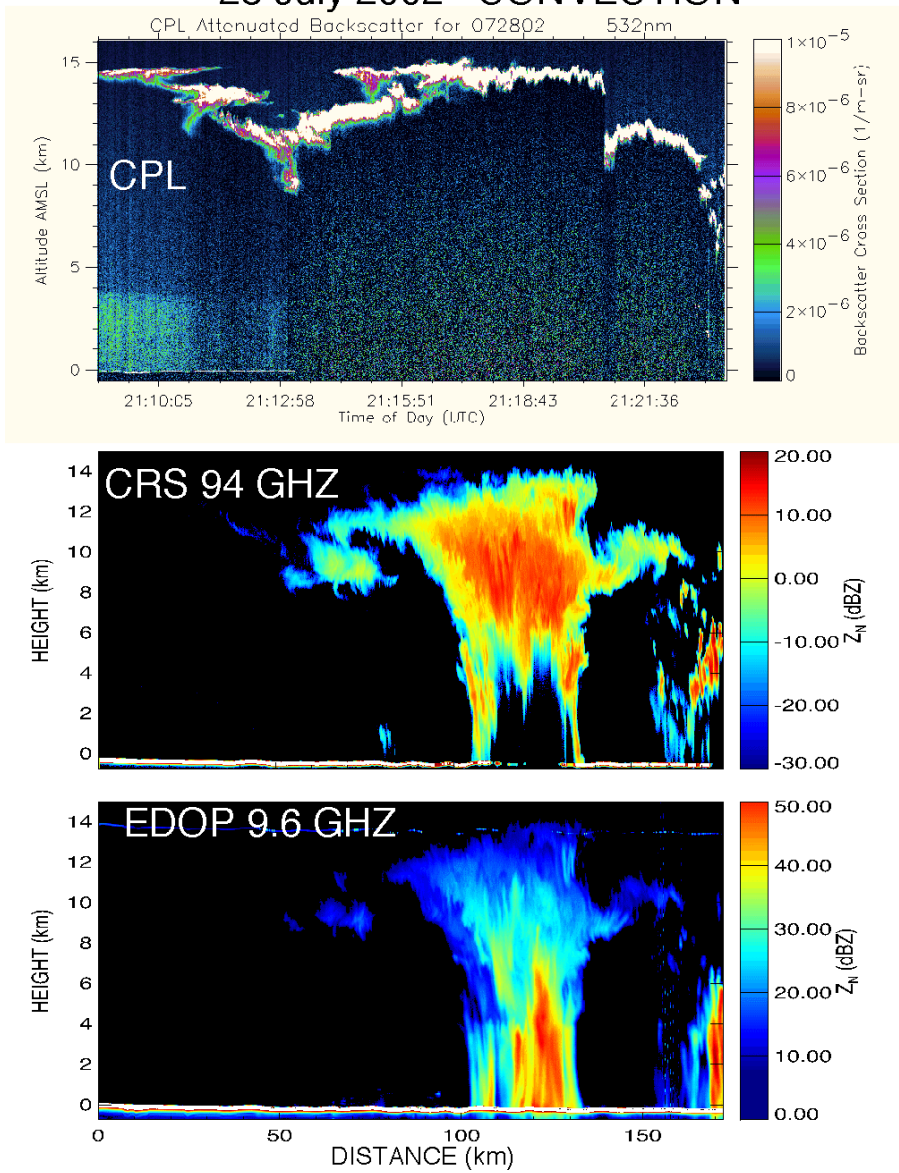


D. Starr/GSFC

CRYSTAL LIDAR-RADAR COMPARISON
19 July 2002 WEAK CIRRUS



CRYSTAL LIDAR-RADAR COMPARISON
28 July 2002 CONVECTION

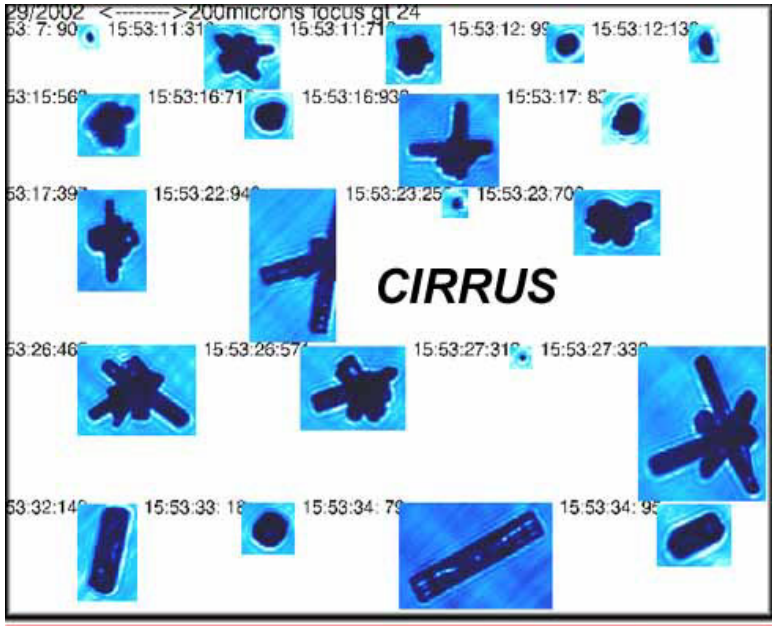


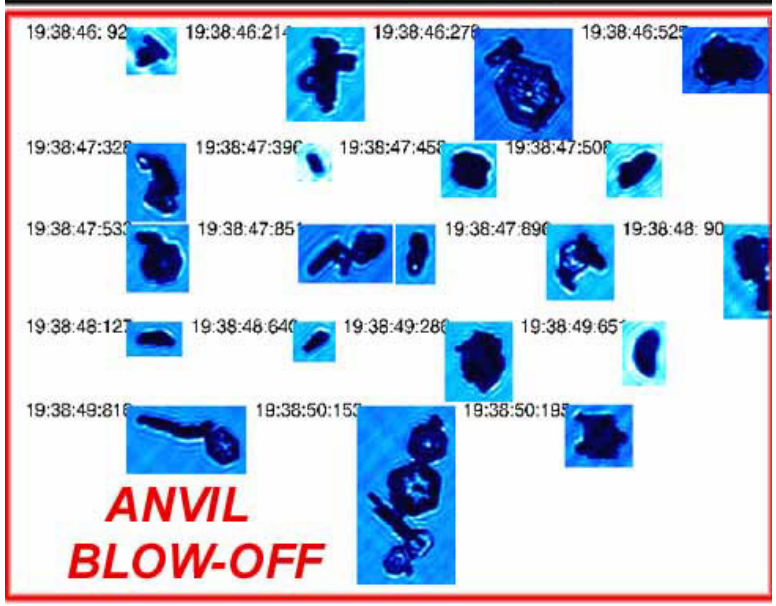
D. Starr/GSFC

NASA WB-57F
CRYSTAL-FACE Payload

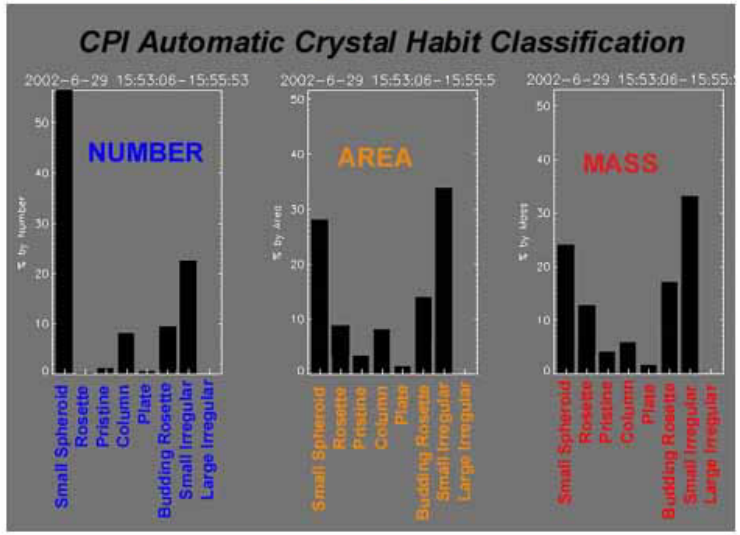
• Anderson	Water Vapor, Total Water	Harvard U
• Herman	Water Vapor	JPL
• Avallone	Total Water and CO2	U Colorado Boulder
• Wofsy	Carbon Dioxide	Harvard
• Rosenlof	Ozone, Methane, Total H2O, P&T	NOAA/AL
• Bui	Temperature and Winds	NASA Ames
• Mahoney	Microwave Temperature Profiler	JPL
• Fahey	Nitric Acid	NOAA/AL
• Ridley	NO and Noy	NCAR
• Webster	CO, H2O isotopes	JPL
• Loewenstein	CO and CH4	NASA Ames
• Elkins	PAN, Methane, Hydrogen, etc	NOAA/CMDL
• Murphy	Aerosol and Ice Nuclei Composition	NOAA/AL
• Buseck	Individual Aerosol Composition	Arizona State U
• Baumgardner	Aerosol Particle Size	Droplet Measurement Tech
• Wilson	Aerosol Size and Collection	U Denver
• Garrett	Scattering Properties of Cirrus	U Utah
• Lawson	Cloud Particle Imager/Cloud Size	SPEC Inc
• Heymsfield	Video Ice Particle Sampler	NCAR
• Valero	Solar and Infrared Radiation	Scripps

D. Starr/GSFC

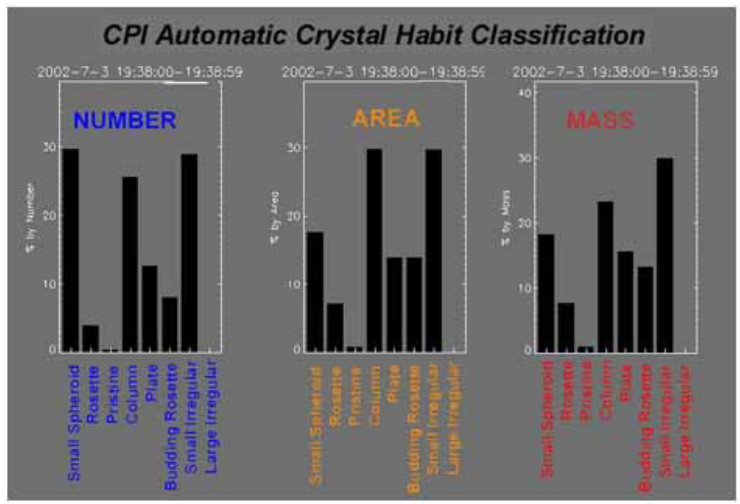




CIRRUS

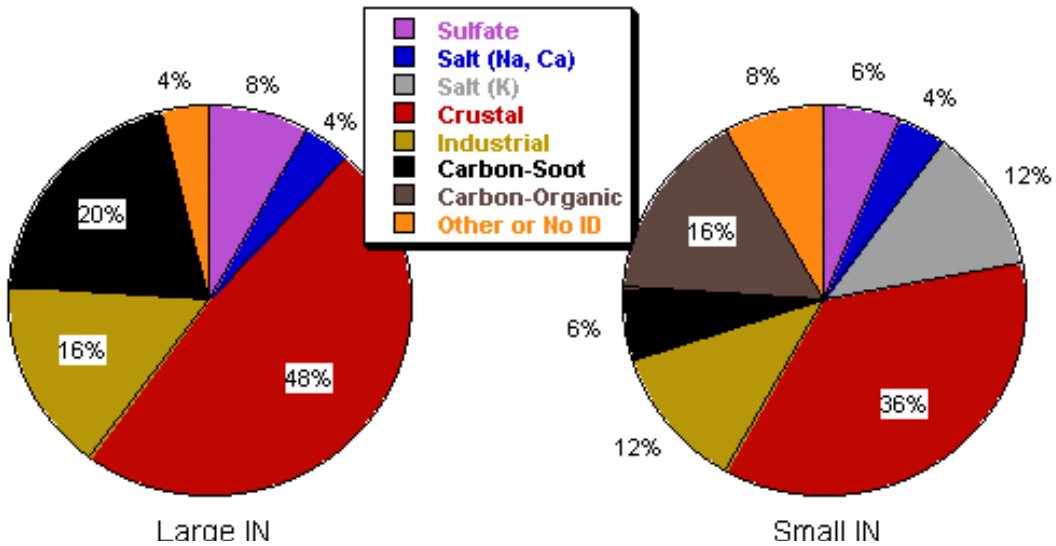


ANVIL BLOW-OFF

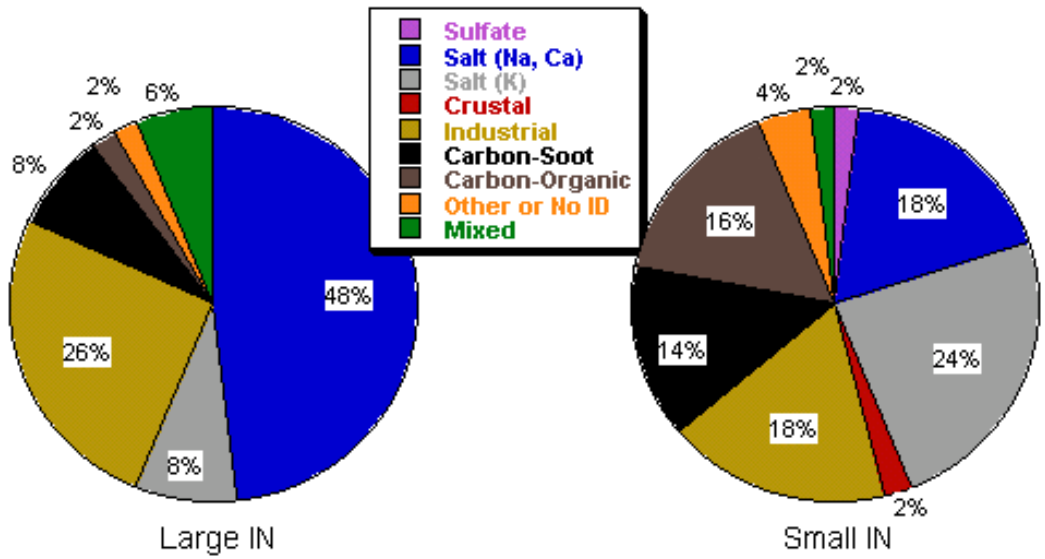


D. Starr/GSFC

CRYSTAL-FACE Composition of Ice Nuclei

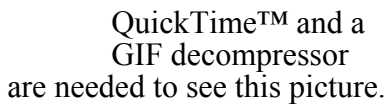


July 3



July 25

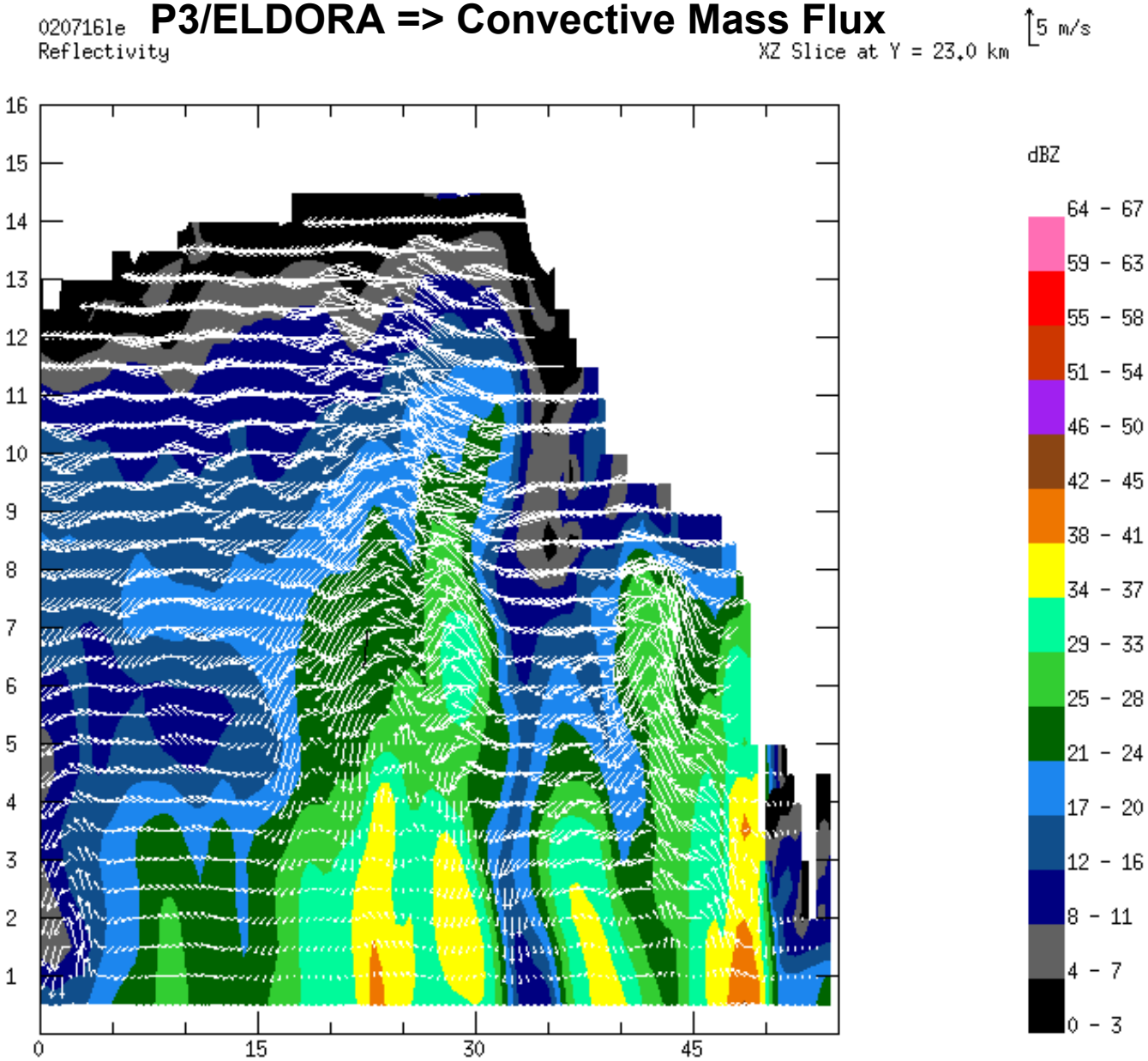
D. Starr/GSFC


QuickTime™ and a
GIF decompressor
are needed to see this picture.


EOS

D. Starr/GSFC

P3/ELDORA => Convective Mass Flux



D. Starr/GSFC

CRYSTAL ….. The Future ??

TC3/TWP Missions in winter/summer 2005 (Guam)

Tropical Composition and Climate Coupling (TC3) and
CRYSTAL- Tropical West Pacific (TWP) Experiments

The A-Train……

Aqua (5/02) - MODIS, CERES, AIRS, AMSR-E

Aura (1/04) - MLS, HIRDLS, OMI, TES

CLOUDSAT (4/04)

CALIPSO (4/04)

We got mosquitoes….

Yes, mosquitoes….

D. Starr/GSFC

…….and Big Al……..

D. Starr/GSFC